

Electric field effect in correlated oxide systems

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Field effect transistors are ubiquitous devices, with $\sim 10^{18}$ of these electronic switches being fabricated each year (Nature, 424, 1015 (2003)). While typically applied to semiconductors, the electric field effect has been used recently in correlated oxides to modulate exotic types of electronic behavior such as superconductivity and magnetism. Figure 1 is a schematic of a field effect device.

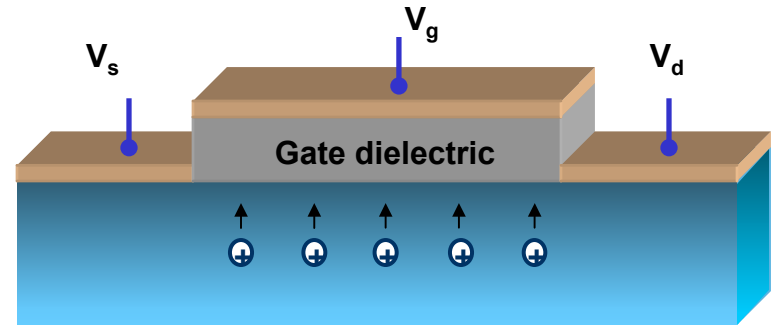


Figure 1. Schematic of a field effect device.

We have applied the ferroelectric field effect approach to the colossal magnetoresistance (CMR) oxides, changing the electronic and magnetotransport properties of these materials. This approach requires the growth of smooth, epitaxial heterostructures consisting of CMR oxides and ferroelectric oxides using advanced physical vapor deposition techniques. Figure 2 is a topographic image of the surface of an epitaxial CMR film taken using atomic force microscopy (AFM). Terraces separated by atomic steps are seen on the 2 μm x 2 μm scan area. Working with these ultrathin, atomically smooth epitaxial oxide films, we plan to modulate the rich functionalities found in correlated oxides, such as the metal-insulator transition shown schematically on the phase diagram (Figure 3).

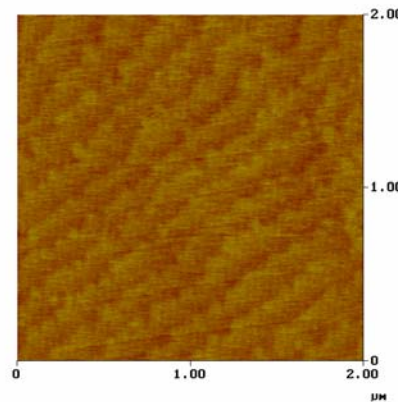


Figure 2. AFM image of the surface of a CMR film.

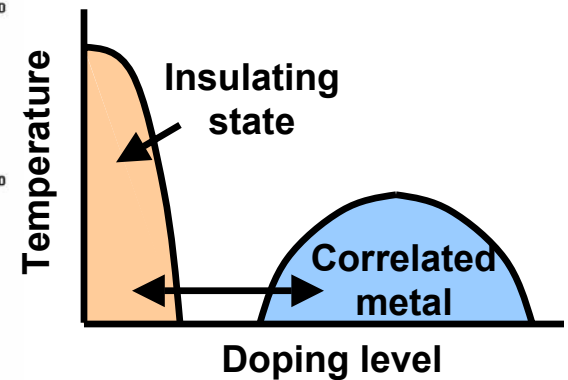


Figure 3. Schematic phase diagram of a correlated oxide.

Field effect transistors are ubiquitous devices, with $\sim 10^{18}$ of these electronic switches being fabricated each year (Nature, 424, 1015 (2003)). The goal of this research program is to investigate field effects in novel materials in order to acquire a deeper understanding of their physical properties. In particular, we examine correlated electron behavior, such as high temperature superconductivity and colossal magnetoresistance. This program entails research in physics and materials science, and requires expertise with advanced fabrication tools, such as off-axis magnetron sputtering, as well as with analytical techniques, such as x-ray diffraction, atomic force microscopy, and low temperature transport measurements. The education program focuses on the teaching and training of undergraduate and graduate students in thin film deposition.

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Education and outreach:

A key component of the laboratory's research involves the growth and characterization of high quality, epitaxial thin films of complex correlated oxides. To the right is a picture of an advanced physical vapor deposition system designed, built, and operated by undergraduate students in the laboratory.

